APPENDIX N:

Cause-and-Effect Analysis of Factors Affecting the Natural Biological Diversity and Natural Biological Diversity

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CAUSE-AND-EFFECT ANALYSIS

With Respect to Natural Biological Diversity and Natural Habitat Conditions, with Emphasis on Marsh and River Habitats

on Stillwater National Wildlife Refuge,
Stillwater Wildlife Management Area, and
Fallon National Wildlife Refuge

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INTRODUCTION

Developing management objectives and strategies for national wildlife refuges in a biologically, scientifically, and legally sound fashion is essential if the National Wildlife Refuge System is to "stand as a monument to the science and practice of wildlife management," as was one of the intents of Congress in passing the National Wildlife Refuge System Improvement Act of 1997 (House Report 105-106). This will require a directed approach to wildlife management founded in ecological and wildlife management principles and scientific information, as opposed to management that is pulled here and there by short-term, perceived emergencies and changing interests. This in turn will require that the objectives and strategies contained in comprehensive conservation plans be developed in a way that focuses management attention on the underlying factors governing the achievement of wildlife and habitat goals and that objectives and strategies are founded in sound principles and available science. Furthermore, the Refuge System Improvement Act requires, as part of the comprehensive conservation planning process, the Service to identify the significant problems that may adversely affect populations and habitats of fish, wildlife, and plants with the planning unit and the actions necessary to correct or mitigate such problems.

Carrying out a cause-and-effect analysis using sound principles and available scientific information can contribute toward meeting these needs. Cause-and-effect analyses are used to isolate underlying reasons why desired conditions are not being achieved (Coughlan and Armour 1992, DeLong 1995). This report begins with an overview of the comprehensive conservation planning process at the Stillwater National Wildlife Refuge (NWR) Complex, which includes Stillwater NWR, Stillwater Wildlife Management Area (WMA), and Fallon NWR. This is followed by a description of the methods used in analyzing problems occurring on Stillwater NWR and the results of the cause-and-effect analysis. The report ends with a discussion of several management applications of the result of the cause-and-effect analysis.

MANAGEMENT CONTEXT

A comprehensive conservation plan is being developed for the Stillwater NWR Complex. Under two alternative boundary revisions for Stillwater NWR, all or major parts of Stillwater WMA and Fallon NWR would be added to Stillwater NWR. Lands not included within Stillwater NWR under the alternatives would be relinquished. Because this report only addresses problems existing within the Stillwater NWR, Stillwater WMA, and Fallon NWR (lands within the potential new boundary of Stillwater NWR), references to Stillwater NWR Complex hereafter do not include Anaho Island NWR.

Based on refuge purposes outlined in the Truckee-Carson-Pyramid Lake Water Rights Settlement Act of 1990 (Title II of Public Law 101-618), and ensuring consistency with the NWRS mission, pertinent legislation and executive orders, Service policy, and international treaties, the following goals have been proposed for Stillwater NWR: (A) conserve and manage fish, wildlife, and their habitat to restore and maintain natural biological diversity; (B) fulfill obligations of international treaties and other international agreements with respect to fish and wildlife; and (C) provide opportunities for scientific research and wildlife-dependent recreational uses that are compatible with refuge purposes. A common theme of the international treaties that apply to Stillwater NWR is the restoration of natural ecosystems and natural habitats. Consequently, the focus of wildlife and habitat management under these goals is on the approximation of natural biological diversity, recognizing that adjustments in management may be needed to address the needs of certain wetland-dependent bird species. Natural biological diversity comprises the diversity within and among biotic communities that evolved in the Lahontan Valley under geological, evolutionary, and other ecological processes apart from human influence, which is consistent with U.S. Fish and Wildlife Service (Service) definitions of "natural" and "biodiversity."

Refuge managers are bombarded with large numbers of problems and issues, especially on more complex refuges like Stillwater NWR. Faced with so many issues and challenges, it is imparitive that managers prioritize the issues to be addressed (e.g., the significant problems), due to limited budgets and staff, to ensure that sufficient resources are applied toward resolving the problems that are ultimately limiting the accomplishment of refuge purposes. One tool that can assist managers is a diagram that illustrates the many cause-and-effect relationships and the ultimate, root causes of the major problems limiting achievement of refuge purposes. The purpose of this report is to identify the problems facing Stillwater NWR/WMA and Fallon NWR and to identify the underlying reasons why these problems exist.

SUMMARY OF THE PROBLEM

As is discussed later in this report, there are long lists of problems on the Stillwater NWR Complex, as with most every refuge in the Refuge System. But what are the ones of primary concern on the refuge complex?

Traditionally, the main interest has been waterfowl and, more recently, shorebirds and other waterbirds have received increased interest. Regardless of the management direction that is adopted at the end of the current planning process, these groups of birds will continue to be a focal point of management. Prior to the onset of the water-rights acquisition program for Lahontan Valley wetlands, significant reductions in water supply, as compared to natural conditions and even as compared to the early and mid-1900s, greatly impacted the number of waterfowl and other waterbirds using the Lahontan Valley for nesting, migration, and wintering. This led to a water-rights acquisition program for Lahontan Valley wetlands, including Stillwater NWR. However, even with the implementation of the wetlands water-rights acquisition program outlined in the Final Environmental Impact Statement for Water Rights Acquisitions for Lahontan Valley Wetlands (USFWS 1996), water supply will continue to be a concern due to: continued litigation of the program and individual water-rights transfers, uncertainty of obtaining anticipated supplies from some sources (e.g., Naval Air Station-Fallon, groundwater, leased water), which comprise a considerable amount of the targeted volume. Assuming that the water rights acquisition program is completed, the volume of water would only be marginally sufficient to restore Stillwater Marsh given the purposes for which Stillwater NWR is to be managed.

In addition to the reduced water flows into Stillwater Marsh and other Lahontan Valley wetlands due to the Newlands Project and agriculture and other water users, contamination of wetland inflows has also become a concern. With agricultural drainwater being the only wetland inflow outside of spill years, concentrations of total dissolved solids and trace elements rose significantly over natural conditions. In the 1980s, concentrations of arsenic, boron, selenium, sodium, mercury, and unionized ammonia were found to be above Federal and State criteria for the protection of aquatic life and propagation of wildlife. These trace elements and other toxins pose a threat to the area's waterbirds and other wetland wildlife. Although the acquisition of additional water rights will continue to reduce these impacts, through reductions in drainwater inflow (as less water is applied to farm fields near the refuge) and dilution of drainwater that continues to flow into the refuge, contaminants will continue to be a concern. Any use of groundwater may, depending on where pumping occurs, offset gains made through acquiring water rights. Furthermore, increasing the rate of inflow of spill-waters from Lahontan Reservoir during large flood events brings with it the potential to increase the rate of mercury importation.

Notwithstanding, however, wetland inflow volumes and most contaminant concerns are being actively addressed through the ongoing, water-rights acquisition program. As yet, there are two significant threats to native plant and animal communities on the Stillwater NWR Complex that have not been addressed to any large degree: the introduction and spread of non-native species and mercury contamination. Likely the greatest threats at present are the singular and combined impacts of non-native species, especially saltcedar, Russian olive, perennial white-top, cheatgrass, cattle, European carp, various species of gamefish, mosquito fish, bullfrogs, and European starlings. These and other non-native species can have marked impacts on native wildlife communities and populations. Saltcedar has completely altered some habitats to the exclusion of many species of native wildlife; non-native fish now dominate fish communities; livestock grazing is one of the leading factors that has dramatically altered several native vegetation communities and associated wildlife; cheatgrass has the potential to completely alter upland vegetation communities to the exclusion of native species; bullfrogs are likely a significant contributing factor to the near eradication of leapord frogs in the area; and European starlings are aggressive competitors that have likely significantly altered the community of cavity-nesting species along the lower Carson River.

In the lower Carson River, the major factors that continue to impair riverine and riparian habitat are a significantly reduced water supply, spread of non-native vegetation (especially saltcedar, Russian olive, and white-top), and season-long livestock grazing. All of these factors are interrelated, the results of which is a markedly altered river and riparian community. Yellow-billed cuckoos, yellow-breasted chats, western harvest mice, and freshwater invertebrates no long inhabit the area and the diversity of neotropical migrants is far below the potential of the area. Another potential problem of the Carson River system no longer functioning in its natural condition is that the river no longer carries sand deposits to its delta, which could potentially impact the dune system along the southern shore of the Carson Sink.

Although human disturbance likely does not impact native wildlife communities to the same degree as altered hydrology and introduction of non-native species, it has the potential to measurably affect these communities under the existing public-use management program. The Service is required to ensure that public use activities occurring on Stillwater NWR do not measurably impair the Service's ability to restore the area's natural biological diversity.

CAUSE-AND-EFFECT ANALYSIS

A cause-and-effect analysis can provide important links between goals and objectives or between objectives and strategies by identifying the underlying reasons why goals or goals are not being reached. A cause-and-effect analysis is much more than problem identification (Coughlan and Armour 1992, DeLong 1995). By conducting a cause-and-effect analysis, long-range objectives and/or subsequent strategies can be formulated in such a way that they focus limited resources on the root of the problem, thereby avoiding a band-aid approach to management.

Coughlan and Armour (1992) discussed the problem analysis process in detail, presenting several different methods of analyzing problems. To examine cause-and-effect relationships between wildlife and plants, their habitat, and the processes that shape habitat at Stillwater NWR, the Watson's circles approach was used and it was supplemented by a cause-and-effect tree. The Watson's circles technique is fairly "user friendly" and can be used in conjunction with one or more other methods such as cause-and-effect trees. Whereas Coughlan and Armour (1992) specified that Watson's circles were useful for evaluating the causes of problems when 10 or less problems are involved, it can be used with many more problems than this. However, the more problems it is used to analyze, the messier and more confusing the process becomes. Cause-and-effect trees are useful for exploring problems further.

Methods

An all-day planning meeting was conducted on 12 June 1997 at the Stillwater NWR Complex office in Fallon, Nevada. The meeting began with an explanation of the basis and rationale for conducting a cause-and-effect analysis, and an explanation of the analysis itself. Also presented was a summary of estimated natural hydrologic and vegetative conditions. Participants of the meeting were:

> Stillwater NWR Complex Office:
> Bob Flores, Deputy Refuge Manager
> Bill Henry, Wildlife Biologist
> Rob Bundy, Wildlife Biologist
> Bob Henderson, Eng. Equipment Operator/Law Enforcement Officer
> Janet Schmidt, Outdoor Recreation Planner
> Don DeLong, Wildlife Biologist/Planning-team Leader
> Ecological Services, Nevada State Office in Reno:
> Mary Jo Elpers, Supervisor, Federal Projects, Permits, and Licenses
> Pete Tuttle, Assistant Contaminant Specialist

Problem Identification

The first step was to list all pertinent problems and their symptoms. To make the process easier to follow and to simplify future steps, major-category headings were identified at the top of several pieces of flip-chart paper taped to the walls. Participants were then asked to start identifying problems and their symptoms that they perceived within the Stillwater NWR Complex. These were listed on a flip chart under the appropriate headings. "Problems" included limitations to achieving natural ecological conditions, recognizing that some of these limitations may not be considered a problems given other goals and objectives (i.e., those not targeting natural conditions).

Cause-and-effect Analysis

The Watson's circles approach was originally published in a business magazine (Watson 1976). This four-step technique has since been used to analyze causes and symptoms of natural resource problems in order to isolate one or more root causes of these problems (Coughlan and Armour 1992). After identifying all pertinent problems and their symptoms, the list was shortened by combining similar problems because the Watson's circles technique becomes cumbersome with large numbers of problems. These representative problems were written on a paper-covered wall. Each problem was circled, leaving a relatively large amount of space around each circled problem to allow room for arrows to be drawn.

The third step was to identify the cause-and-effect relationship between problems. For each circled item, an arrow was drawn from each problem to all other problems that the particular problem causes or helps to cause (i.e., its symptoms). Participants then considered the following questions for each circled problem: "to what other problems does this problem lead or contribute?" (draw arrow toward other circles) and "what are the causes of this problem?" (arrow is drawn from other circles toward this one). The fourth step was to sort through the network of arrows to isolate the root cause(s) of the problems (Fig. 1c). Root causes of problems are those that have arrows pointing away from them, but none pointing toward them. However, whereas the ultimate goal of the process is to identify root causes of problems, this may not always be a straightforward procedure. The factor(s) that originally caused a particular set of habitat problems (i.e., ultimate causes) may not necessarily be the same that maintain the habitat in degraded condition (proximate causes). This is discussed further in the results section.

Following the identification of root causes of problems by the group using the Watson's circles technique, the hydrologic information was reformatted by the author of this report into a cause-and-effect tree, facilitating a better understanding of the relationships and making cause-and-effect relationships easier to visualize. For instance, by moving progressively backward (backward analysis)(Erickson 1981, Coughlan and Armour 1992) from a given ecological condition, factors producing this condition can be traced back to the ultimate factors that cause the condition.

Results

Problem Identification

Five major categories of potential problems were identified and each was written on the top of flip-chart paper. Using these categories as a guide, a total of 99 potential problems were identified by the group (Table 1), and this list was shortened to 29 representative problems (Table 2). These problems were addressed by the group in the Watson’s circles analysis.

Following the Watson’s circles analysis, the identified problems were assessed by the author of this report to ascertain the major differences between natural and existing ecological conditions in major habitat groups: marsh (e.g., Stillwater Marsh, Battleground Marsh), river/river-riparian (e.g., Carson River, Stillwater Slough), and uplands (e.g., salt desert shrub, sand dunes); and off-refuge environments (Table 3). These problems represent the major symptoms of processes not operating at natural levels, among other alterations to the ecosystem.

Cause-and-effect analysis

The Watson’s circles exercise carried out by Service personnel (Figure 1) and further analysis using cause-and-effect trees (Figure 2) revealed that the following are the major underlying factors affecting biological diversity within the Stillwater NWR Complex that can be addressed on these lands:

- altered topography and restricted flow;
- presence and spread of nonnative species, including domestic livestock; and
- unnaturally-high concentrations of contaminants in soils.

The major underlying factors affecting the Service’s ability to approximate natural biological diversity and natural habitat conditions within the Stillwater NWR Complex, regardless of where the problems must be addressed are as follows. The superscript ‘^{OFF}’ designates off-refuge factors and ‘^{ON}’ designates on-refuge factors, which many times are a result of off-refuge factors (the associated ‘^{OFF}’ factor). Two asterisks (**) indicate the three underlying factors that can be addressed through habitat management on the refuge. One asterisk (*) indicates factors that can be addressed through public use management and wildlife population management on the refuge.

1^{OFF} insufficient amount and altered timing of inflow;
** 1^{ON} altered topography and restricted flow;

2^{OFF} influx of nonnative species (can partially be addressed through management);
** 2^{ON} presence and spread of nonnative species, including domestic livestock;

3^{OFF} inflow of unnaturally-high concentrations of contaminants;
** 3^{ON} unnaturally-high concentrations of contaminants in soils;

4^{OFF} land-use practices throughout the Western Hemisphere (i.e., effects on migratory bird populations);
4^{ON} altered populations on Stillwater NWR

5^{OFF} public interest in using refuge (local-global) and altered populations of predators;
* 5^{ON} altered disturbance, mortality, and possibly predation rates

Table 1. List of factors on Stillwater National Wildlife Refuge, Stillwater Wildlife Management Area, and Fallon National Wildlife Refuge, Nevada, that are different now than they would be under natural conditions (i.e., potential problems).

CONTAMINANTS	**VEGETATION**	**HYDROLOGY**	**WILDLIFE**	**DISTURBANCE**
INTRODUCED	Encroachment of Exotics	Timing (seasonal flow pattern)	Reduction in:	Noise Pollution
Mercury	Increase in Groundwater -	Flow Volume	–riparian-dependent wildlife	Nest Flooding
Pesticides	effects on vegetation	Water Quality	–fisheries	Fire
--herbicides	Livestock Grazing	–salinity	–fishing birds	Change in Deflation
--insecticides	Reduction of:	–nutrients	–burrowing animals	Procedures
--fungicides	--communities of	–crop fertilization	–shorebird populations	Human
Sewage	submergents due to lack of fresh	–dissolved oxygen	–waterfowl population	–roads
Urban Runoff	water	–trace elements	–populations of small	–boats
--petroleum based	--riparian vegetation	More Shallow Water	mammals	–vehicles
--antifreeze	--Great Basin wild rye	Restricted Flow Pattern	Introduction of exotic fish	–hunting
--fertilizers	--Indian rice grass	–diking	–competition	–scientific research
--household chemicals	--vegetation height in	–smaller wetland unit size	Seep Pond Invertebrates	–public use
Accidental Spills	meadows	–high water flows restricted by	Loss of Clams/Mussels	Livestock
Lead Shot	Beaver	dikes	Shift in Aquatic Invert Species	
Ordnance	Change in :	–change in water entry points	Competition of Exotics	
	--proportion of	--groundwater and discharge	(starlings, etc)	
NATURAL	submergents/emergents	–reduced flushing flows	Predation	
Changed Trace Elements in	–upland communities	–proportion of water depth	–ravens	
Soil	--proportion of cattail/bulrush	–loss of floodplain riparian	Introduced parasites/Diseases	
--load increase	(favoring cattail)	–increase in seep ponds	Botulism	
Aluminum	-- insect/plant relationships	–aquatic animal corridor	Feral Predators (cats, dogs)	
Dissolved Solids	-- woody material	restriction		
	--recruitment opportunity	–channelization		
	--size shape of wetlands	–water retention		
	–wetland communities	–loss of flow-through		
	--nesting cover	dynamics		
	Introduction of Agricultural	–delivery through canals (vice		
	Crops	natural)		
	Habitat Fragmentation	–delivery efficiency differs from		
		natural		
		–annual variance		
		–reduction floodplain		
		–loss of river-associated		
		wetlands		
		–introduction of artesians		
		–restricted river channel		
		dynamics		
		–maintenance of hydric soils		
		–sediment deposition		
		Change in Flow Due to		
		Flooding		

Table 2. Consolidated list of potential problems from Table 1, used in the Watson's circles analysis.

CONTAMINANTS	VEGETATION	HYDROLOGY	WILDLIFE	DISTURBANCE
Introduced	Change in upland communities	Timing of flows	Reduction in riparian-dependent wildlife	Human disturbance
Natural	Change in wetland communities	Flow volume	Introduction of exotic animals	Nest Flooding
	Change in riparian communities	Water quality	Fisheries and herp reduction	Livestock
	Encroachment of exotics	More shallow water	Reduction of burrowing animals	
	Beaver	Restricted flow	Parasites/diseases	
		Ground water	Change in waterfowl/water birds	
			Change in shorebirds	
			Change in aquatic inverts	
			Predator increase	
			Predator decrease	

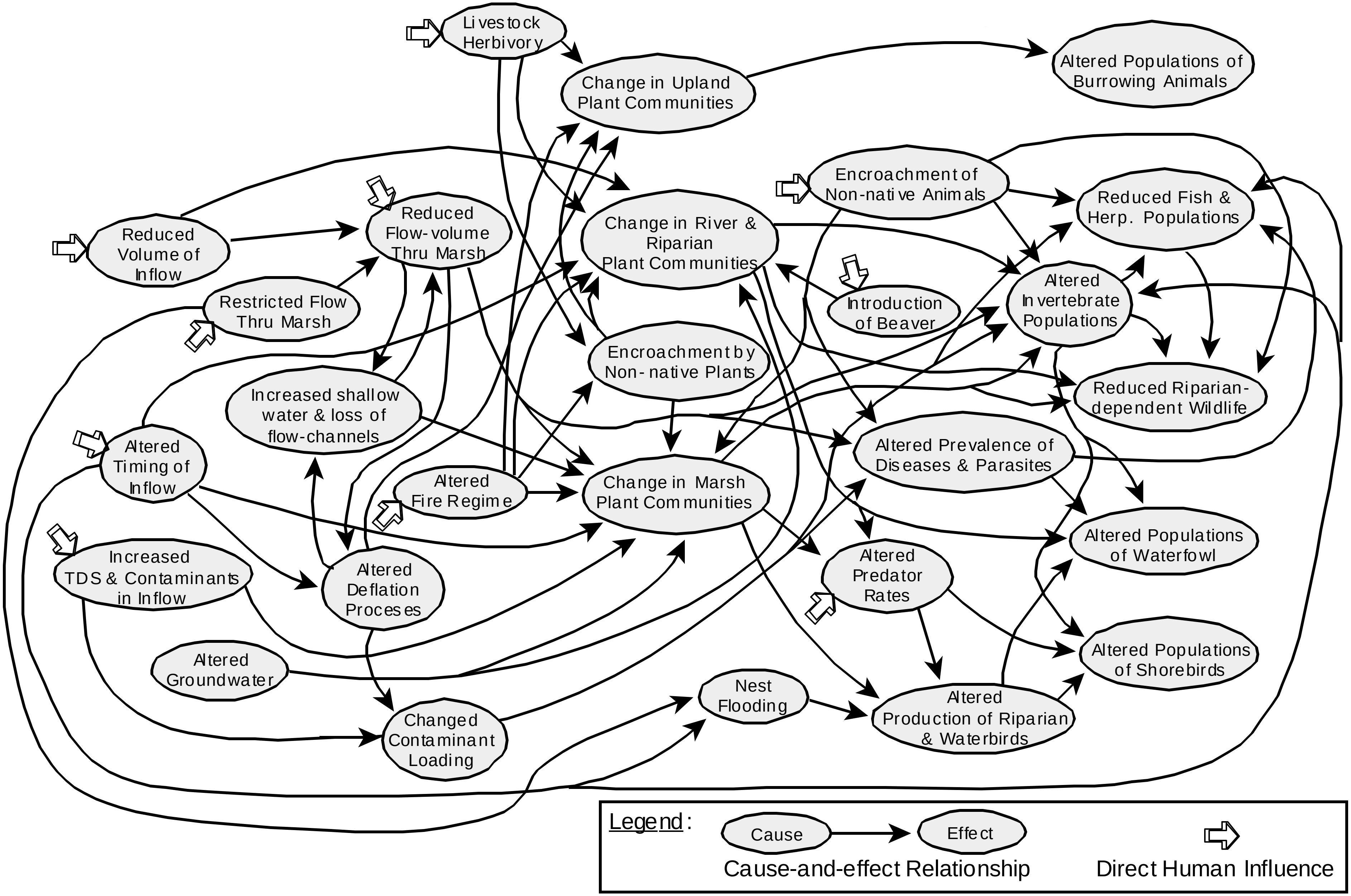
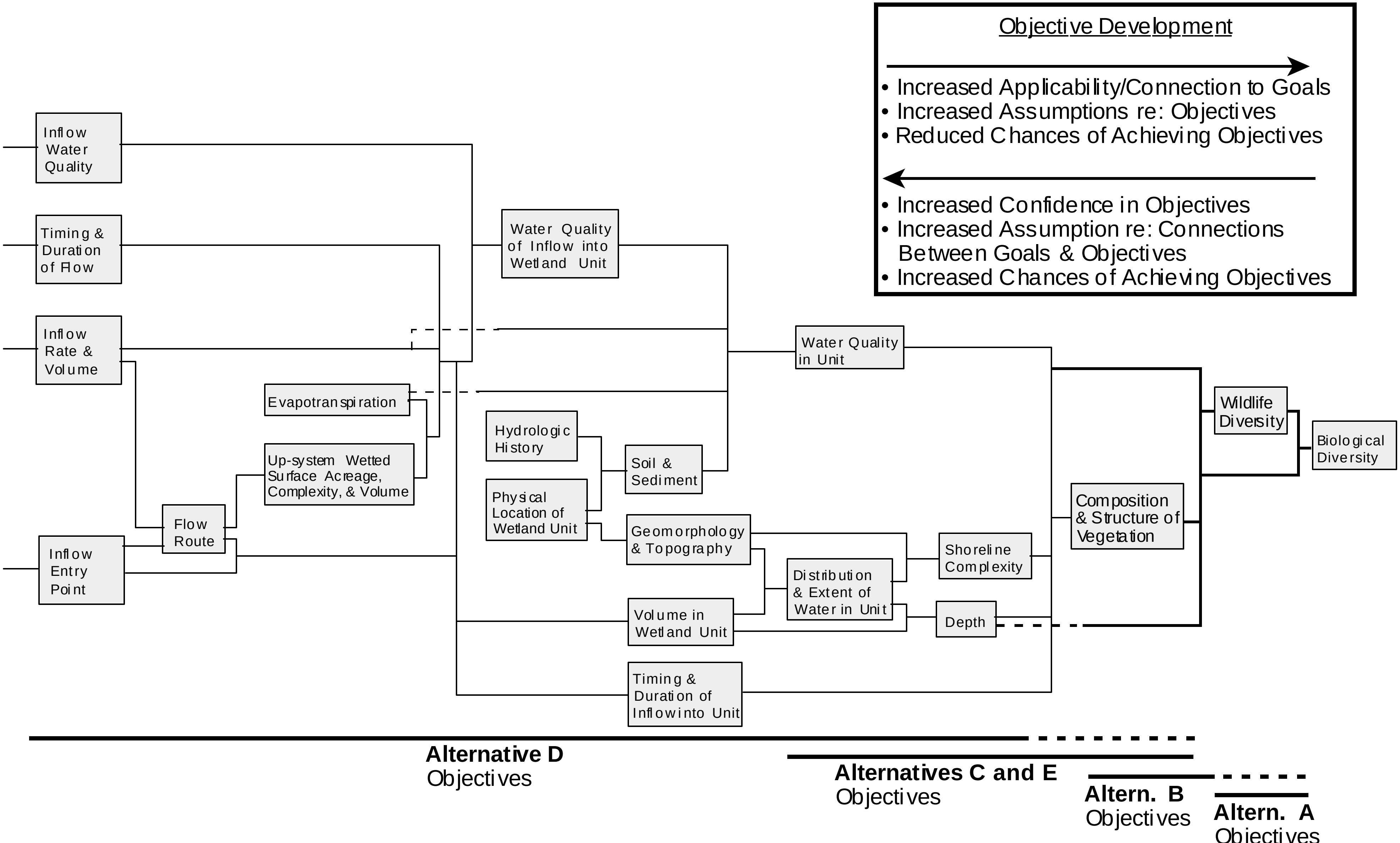


Figure 1. Watson's circles excercise carried out by U.S. Fish and Wildlife Service personnel (as modified by the author) fordetermining the underlying factors limiting the approximation of natural biologiial diversiity within the proposed boundary of Stilillwater National Wildlife Refuge, Nevada.

Hydrologic Factors Affecting Biodiversity on Stillwater NWR

(& their Relationship to Objective Development)



Factors 1-4 appear to have the most influence on the Service's ability to approximate natural biological diversity on Stillwater NWR. Factors 1^{ON}, 2^{ON}, and 3^{ON} are the main on-refuge factors that must be addressed in the comprehensive conservation plan with respect to fish, wildlife, and plant conservation. Factor 5^{ON} is also addressed in the plan because (a) all public uses of Stillwater NWR that are allowed to continue must first be shown to not measurably impair the Service's ability to approximate natural biological diversity (among other compatibility issues), (b) public use of the refuge is increasing, and (c) addressing nest depredation was identified as an issue of interest to the public.

Because the ultimate causes of Factors 1^{ON}, 2^{ON}, and 3^{ON} originate outside of the proposed refuge boundaries, the comprehensive conservation plan should address the potential of forming partnerships, cooperative management, and other off-refuge Service programs to address them. Not addressing these off-refuge factors (Factors 1^{OFF}, 2^{OFF}, and 3^{OFF}) will hamper the Service's effectiveness in resolving Factors 1^{ON}, 2^{ON}, and 3^{ON}. For example, efforts to resolve insufficient flow volumes through the wetlands (likely the most significant problem facing Stillwater NWR) by only addressing on-refuge factors (Factor 1^{OFF}) will have only limited success because these problems are overridden by inadequate inflow volumes (Factor 1^{ON}). Factor 1^{OFF} is being addressed through an ongoing water-rights acquisition program (USFWS 1996). The program specifically addresses the conversion of waterflow from agriculture and other use back to where the water had originally flowed, the Lahontan Valley wetlands. This factor also is partially addressed in a 1998 agreement between the Bureau of Reclamation, Service, and TCID that outlines a priority system for "excess" water.

The results of the cause-and-effect analysis are discussed in more detail below

1. Hydrology

<u>1^{E} - Effects on Natural Biological Diversity</u>

The major factor that has and continues to affect the natural biological diversity within the proposed boundaries of Stillwater NWR is altered hydrology; e.g., significantly reduced volume (and rate) of water flowing through the lower river and marshes, altered timing of water flowing through these habitats, and pattern of flow through the marshes. Of these, water volume is the most critical.

Some of the components of the natural biological diversity that have been adversely impacted include the number of migratory birds breeding in the wetlands, production of migratory birds and other wildlife, presence and abundance of certain species of invertebrates, overall extent of marsh vegetation, prominence of particular plant communities (e.g., diminished amount of fresh-water plant communities), and successional pathways. The amount of waterfowl use that Stillwater NWR receives during fall and winter is largely influenced by the amount of wetland habitat that is available (Figure 4.1, Volume I, Draft EIS). Prior to the wetlands water-rights acquisition program, available wetland habitat in the Lahontan Valley had declined by an estimated 80-90 percent, as compared to estimated natural conditions. Wetland habitat in the early spring has been especially hard hit. Because use of the wetlands by breeding birds is closely tied to the amount of habitat available during the spring, it is presumed that migratory birds have been significantly impacted.

Although the significant reduction in wetland-habitat acreage is likely the major factor affecting these components of natural biological diversity, the significant reduction in flow rates of fresh water into and through the marsh has likely led to marked changes in marsh ecology and the diversity of species that are seen today. Loss of deeper-water channels running through the marsh has likely impacted native fish and other wildlife by reducing the number of areas that could retain small acreages of water (e.g., low surface area and thus low evaporation) during droughts, although this impact is likely outweighed by the overall reduction in wetland inflows and introduction of nonnative fish.

Table 3. Listing of major problems categorized by ecological zone on Stillwater NWR, Stillwater WMA, and Fallon NWR, Nevada.

Ecological Zone	Major Problems
Marsh	
	1) **Reduced amount and altered distribution and chemistry of water**; including elevated concentrations of dissolved solids and potentially-toxic trace elements in water column;
	2) **Altered geomorphology and soil chemistry**, including absence of deeper channels running through marsh, fragmentation of marsh, absence of one contiguous body of water in Stillwater Marsh, increased salinity/alkalinity of soils, and presence of elements such as mercury in the soil column;
	3) **Altered vegetative composition and structure**, including emergent marsh and shoreline species replaced by salt cedar, presence of shrub component along the edge and interior of marsh (salt cedar), reduced cover of emergent vegetation, increased relative composition of emergent and submergent vegetation associated with higher concentrations of dissolved solids, and low graminoid height along edges of marsh; and
	4) **Prevalence of nonnative fish and wildlife**, including carp, mosquito fish, a variety of game-fish and other nonnative fish species, and bullfrogs.
River & River-Riparian	
	1) **Reduced amount of water in river during all seasons and years and changed chemistry of water**, including reduced volume of water in the river at any give time, absence of perennial water, altered timing of peak water in river, lack of water overtopping [formerly] wet meadow communities, absence of water in side-channels, acreage of wetland habitat, increased stagnation and elevated water temperatures, elevated concentrations of dissolved solids and potentially-toxic trace elements in the water column;
	2) **Altered geomorphology and soil chemistry**, including reduced sinuosity, increased ratio of channel dimensions:water volume (i.e., reduced bank overflow), and presence of toxic elements in the soil such as mercury;
	3) **Altered vegetative composition and structure**, including reduced species richness in plant communities, reduced composition (or absence) of sedges and rushes along river banks, reduced graminoid/forb height, reduced density of grasses, presence of a shrub overstory in wet meadow communities, reduced overstory of tall trees (cottonwoods), and willows, roses, buffalo berry, and cottonwood replaced by salt cedar and Russian olive (e.g., altered composition and structure of shrub layer and tree canopy; and
	4) **Prevalence of nonnative fish and wildlife**, including carp, mosquito fish, a variety of game-fish and other nonnative fish, and bullfrogs, European starlings, and house sparrows (to name a few).
Uplands	
	1) **Altered vegetative composition and structure**, including density of perennial bunch grasses, dominance of underscore by nonnative annual grasses (e.g., cheatgrass), reduced grass/forb height, and dispersed perennial bunch grasses replaced by closely spaced annual grasses; and
	2) **Cessation of movement (replenishment) of sand into dune areas**,
Off-Refuge Conditions	
	1) **Impediments to river flow**, including Lahontan Reservoir, diversion dams, and canals conveying water from the river;
	2) **Degraded habitat conditions** in the Lahontan Valley, along the Carson River, and throughout North, Central, and South America.
	3) **Depressed populations of native fish and wildlife populations** that will not provide an immigration source — e.g., absence of native fish in Carson River, fragmentation of riparian corridor for movement of riparian-associated small mammals, and reduced populations of migratory bird species; and
	4) **Prevalence of nonnative fish, wildlife, and plant species** that can and will continue to move onto the refuge from surrounding lands, including European carp, various game fish, mosquito fish, European starlings, salt cedar, tall white-top, and purple loosestrife.

Results of the cause-and-effect analysis are consistent with contemporary principles of river and marsh ecology and other aspects of biodiversity conservation. Specifically, the reduced volume and altered chemistry, timing, and flow-patterns can significantly alter biological diversity of marsh and riverine ecosystems (Doppelt et al. 1993, Stanley et al. 1997, Ward 1998), which appears to be true also of Stillwater Marsh and the lower Carson River and its delta near Battleground Point.

Several factors have likely led to the reduction in the distribution and canopy cover of cottonwood stands and their understory along the lower Carson River, but the significantly reduced water supply (primarily in terms of frequency of flooding, but also the volume of water and timing peak flows). In other areas, the cessation of the annual flooding and scour cycle of rivers has led to thinning of cottonwood stands and replacement by nonnative plant species (Stalnaker 1999).

Diversity of neotropical migratory birds has undoubtedly been affected by the significantly altered riparian cottonwood communities. About 50 miles away on the lower Truckee River, bird species requiring dense understory of woody riparian vegetation that were common or abundant in 1868 were less common or absent in similar counts made in 1972, 1975, 1976, 1980, and 1981 (Klebenow and Oakleaf 1984). According to the authors of the study, "Shrub and thicket inhabitants that were completely missing from the recent surveys included the Yellow-billed cuckoo, Black-chinned hummingbird, Willow flycatcher, and Yellow-breasted chat (Klebenow and Oakleaf 1984:207). River-channel alterations and conversion to farmland were likely the major factors that adversely impacted riparian vegetation, although livestock grazing was reported as a contributing factor.

Lack of native trees along the lower Carson River and the introduction of exotic species of plants was put forth as the most likely cause of lower-than-expected numbers of bats in this area (Rahn 1999). Cottonwoods are the only native tree of sufficient size to accommodate these bat species. Deteriorated riparian habitat was also identified by Charlet et al. (1998) as impairing higher use of the area by several species of small mammals including desert woodrats, and possibly bushy-tailed woodrats.

1^{ON} - Altered Topography and Restricted Flow through the Marsh

Stillwater Marsh was once one large, contiguous marsh having several deeper channels running the length of the marsh. It is now subdivided into numerous smaller units and the deeper channels have long since filled with sediments. Notwithstanding the restrictions leading to Stillwater Marsh, there are several differences between existing and natural wetland conditions that limit the volume of water that can now flow through the marsh (assuming more inflow is available):

(1) significantly smaller bottlenecks (i.e., small water-control structures compared to comparatively wider spacing between peninsulas and islands);
(2) far fewer spaces between islands and peninsulas (i.e., dikes now span between islands and peninsulas);
(3) flat and nearly flat substrate across wetland units and an absence of sloughs through the marsh (all sloughs have long-since been covered with sediment).

At present, a maximum of only about 450 cfs can be passed through the marsh from several points of entry without damaging water-control facilities and roads, as compared to several thousands of cfs that flowed through the marsh during spring runoff in most years under natural conditions and up to 10,000-20,000 or more cfs during especially high flows. This means that, even with additional water acquisitions and increased conveyance of "excess" water to Stillwater NWR, the refuge could not safely accommodate much more than about 450 cfs. Waterflow through most wetland units of the marsh rarely, if ever, exceeds 150 cfs in high-water events.

High-volume pulses of water during spring runoff were important features of the natural marsh hydrology. They served to flush accumulated salts out of the marsh (thus maintaining a fresher-water system), resuspend deposited sediments and push them through the marsh (thus maintaining deeper-water areas of the marsh and prevented the marsh from silting in), and scour vegetated areas and flatten emergent vegetation (thus creating openings and new channels). Deeper-water channels running the length of the marsh maintained by these high flows allowed the marsh to fill quicker in the winter and early spring and allowed larger volumes of water to pass through the marsh. These processes do not occur or are greatly impaired under existing conditions.

On-refuge flow restrictions are not a problem on the lower Carson River and Battleground Marsh. However, flow volume is significantly restricted up-river (only a maximum of about 1,800 cfs can safely be released from Lahontan Reservoir and a maximum of 800 cfs can be conveyed under the Tarzyn Road bridge.

Management Implications. The most pertinent management implication under this heading is the need to increase the capacity of on-refuge water-control facilities. Obviously, the rate of flow will be ultimately restricted by the amount that can safely be released from Lahontan Reservoir (a small fraction of historic flows into the marsh) and conveyed to Stillwater NWR via Newlands Project canals. Off-refuge flow restrictions are addressed in the next section.

As part of their contract to the Service, Ducks Unlimited currently is ascertaining the feasibility of modifying water control structures, canals, and other water control facilities to increase the volume of water that can be conveyed through different parts of the marsh.

Although the flatness of the marsh certainly limits the flow of water through the marsh, deeper-water channels through the marsh could help offset this factor. Furthermore, upper units would not necessarily have to be filled to deliver water to lower units.

<u>1^{OFF} - Insufficient Amount and Altered Timing of Inflow</u>

Reduced volumes of water flowing through Stillwater Marsh has primarily been a consequence of reduced volumes of water flowing down the lower Carson River, but it also resulted from construction and operation of irrigation canals and drains in the Carson Division of the Newlands Irrigation Project that prevent large volumes of water from reaching the marsh. Whereas natural seasonal-peak flows of the Carson River into Stillwater Marsh were on the order of several thousand cfs upwards to 20,000 or more cfs, the maximum capacity of the canals and drains leading to the marsh is about 450 cfs.

The major factors that have reduced the volume of water flowing down the Carson River into Stillwater Slough, the marshes, and the lower Carson River within the Stillwater NWR Complex are up-river use of water by agriculture, municipalities, and industry, and, related to these, the construction and operation of Lahontan Reservoir for irrigation-water storage and flood control (Thompson and Merritt 1988). Prior to implementation of the water-rights acquisition program for Lahontan Valley wetlands, the average annual volume of water reaching the Lahontan Valley wetlands had declined from an estimated 410,000 AF/year during the late 1800s (Kerley et al. 1993) to just over 40,000 AF/year (USFWS 1996). This is a reduction of about 90 percent. Much of the 410,000 AF estimated to have flown into the Lahontan Valley wetlands flowed through Stillwater Marsh on its way to Carson Sink (roughly 100,000 AF in low water-years to several hundred (possibly up to 600,000 AF or more) in high water-years).

Under the Service's water-rights acquisition program, it is estimated that a long-term average of about 70,000 AF/year of water will reach Stillwater NWR (from as low as 20,000 AF/year to just over 100,000 AF/year). Although this is considerably less than what would flow into Stillwater Marsh under natural conditions, it is a significant improvement over wetland conditions without water-rights acquisitions. This program may very well not have been established if it were not for the support of the

Lahontan Wetlands Coalition and the groups comprising the coalition (Poppoff 1993). Although the efforts of the Lahontan Wetlands Coalition and other groups is an "off-refuge" factor, it is directly tied to the activities that individuals partake on Stillwater NWR (on-refuge activities).

There are several reasons why the seasonal pattern of water flowing through the marsh is different than it was under natural conditions. The major factor is the operation of Lahontan Reservoir dam. At present, the dam is operated in accordance with the 1988 Operating Criteria and Procedures (OCAP) for the Newlands Project, as amended in 1997 (USDI 1988, 1997). OCAP provides guidelines that the Newlands Project operator must follow in managing Lahontan Reservoir and the other project facilities. Other factors affecting the timing of water flowing into the marsh include refuge management decisions (delivery schedule and water management), flow restrictions on and off the refuge, use of water by other water users, limitations on when water can be delivered under OCAP, and water-spreading agreements, among many other factors.

Management Implications. Continuation and completion of the water-rights acquisition program may be the single most important Service action with respect to the conservation of Stillwater's wildlife (natural diversity and otherwise).

Modifying Carson Division canals so that higher volumes of water can be conveyed to the refuge, especially during spill-years, would also address the problem of reduced flow rates to the refuge's marshes and rivers corridors. On a related matter, the U.S. Army Corps of Engineers is studying options for reducing flood potential in the Fallon area. Alternatives that would transport greater volumes of flood waters around the City of Fallon and that would convey this water to the wetlands could accommodate the City of Fallon's objectives as well as those of the Service. Furthermore, any additional water conveyed to the refuge during spill years could reduce the amount of water to be acquired from other sources.

Adherence to criteria in the "Excess Water" agreement should ensure that the refuge receive a portion of water that is released or spilled from Lahontan Reservoir during precautionary releases and spills. This will likely require constant attention during years of precautionary releases and spills.

2. Nonnative Species

2^{E} - Effects of Nonnative Species on Natural Biological Diversity

Another major factor impacting natural biological diversity within the Stillwater NWR Complex is the introduction, continued influx, prevalence, and spread of certain introduced plant species (e.g., saltcedar in riparian and marsh habitats, and cheatgrass in uplands) and animal species (e.g., bullfrogs, European carp, and other fish in marshes, and cattle and European starlings in riparian areas). Worldwide, the introduction of nonnative species is one of the leading causes of degradation of natural biological diversity (Bryant and Barber 1994, Hunter 1996). Impacts of nonnative species on natural biological diversity can be divided into two main groups: (1) effects on plant community composition and structure, and effects of these alterations on native animal species; and (2) effects on animal populations through competition, predation, and disease. The first group can be further divided into two categories: (a) effects of nonnative plants on plant community composition and structure through competition; (b) effects of nonnative animals on native-plant community structure through direct impacts (e.g., reducing grass height and canopy cover, due to cattle grazing); and (c) effects of nonnative animals on plant-community composition and structure through indirect impacts (e.g., reduced cover of native plant species leading to increased cover of nonnative species, due to cattle grazing; increased turbidity of water leading to reduced cover of aquatic vegetation, due to carp feeding). Categories 1a, 1b, and 2 are addressed in more detail below. Category 1c effects are addressed further in the following section, 2^{ON}, as these are indirect impacts to natural biological diversity.

Charlet et al. (1998) concluded that the most serious single problem with the vegetation in Stillwater NWR/WMA and Fallon NWR is the introduction, naturalization, and increased abundance of exotic species, with saltcedar being the primary species they discussed. Saltcedar has a significant impact on some plant communities within the Stillwater NWR Complex. For instance, vast areas of meadow habitat dominated by grasses, rushes, and sedges has converted to saltcedar dominated communities with little underscore. Monotypic stands of saltcedar is replacing mixed deciduous shrub/tree communities in riparian areas and emergent vegetation in marshes. These observations are consistent with studies from other locations (e.g., Busch and Smith 1995, Vitousek 1986). The alterations to natural plant community composition and structure has likely had marked impacts to wildlife communities.

Altered structure of native plant communities due to cattle grazing adversely impacts several components of natural biological diversity. This has been thoroughly reviewed in Appendix M (DeLong 2002b). It directly alters the natural structural diversity of vegetation. Cattle grazing reduced the height and stature of native grasses, rushes, and forbs in meadow and riparian communities. This has shown to affect native bird and small mammal communities, as summarized in Appendix M. This was also addressed in Charlet et al. (1998). Cattle grazing also can reduce the height of deep-emergent communities and thus affect wildlife communities.

Cheatgrass is having considerable impacts to native plant communities in some upland areas of the refuge. Cheatgrass produces extensive ground cover in areas previously characterized by large proportions of open ground. This could impact species requiring spacing between plants, such as kangaroo rats (Price and Brown 1983 and Reichman and Price 1989, as cited by Longland 1993) and lizards. Another attribute of cheatgrass-dominated communities is their propensity for frequent burning. This would have devastating impacts to native salt-desert shrub communities that evolved with very infrequent fires (Young and Tipton 1990). Being an annual, cheatgrass thrives under frequent burning.

European carp, brown bullhead, smallmouth bass, mosquito fish, and other non-native fish dominate the fish communities within the proposed refuge boundary. A total of 29 species of fish have been documented on Stillwater NWR, of which three are native and one of these has not been documented for about 20 years. In addition to this overwhelming effect on natural biological diversity, European carp can have indirect adverse impacts on native biotic communities by increasing water turbidity and markedly reducing aquatic plant production (Moyle et al. 1986; Unpublished data, U.S. Fish and Wildlife Service, Malheur NWR, Oregon), and thus wildlife communities in Great Basin marsh ecosystems. Based on a thorough review of the scientific literature and their observations at Ruby Lake NWR, just to the east of Stillwater NWR, Bouffard and Hanson (1997) suggested that introductions of exotic fish alters native aquatic communities, influences nutrient dynamics and productivity, and modifies natural food webs in many wetlands. Of native North American species, 34 percent of fish and 74 percent of unionid mussels are at risk due to nonnative fish introductions (Wilcove et al. 1992, as cited by Bouffard and Hanson 1997). Several species of game fish inhabiting Stillwater NWR Complex have been shown to significantly affect populations of amphibians in other areas due to predation on eggs, larval, and adults, as well as a variety of indirect effects (Maxell and Hokit 1999). Smallmouth bass, which have been common in Stillwater Marsh in the past, can adversely impact waterfowl broods. Williams (1999) noted that “Almost everywhere introduced mosquitofish have harmed aquatic ecosystems and faunas because of their highly predaceous habits, and they have reduced or eliminated populations of at least 20 other species of fish, including largemouth bass (Schoenherr 1981) and numerous invertebrate species.” Mosquitofish do not only feed on mosquito larvae, the reason for which they have been introduced into countless water bodies, but they also eat other invertebrates and can prey on eggs and fry of other fish, eggs and tadpoles of frogs (Webb and Joss 1997, for study and additional citations).

Bullfrogs, a nonnative invasive species that is common to abundant in some wetlands within the Stillwater NWR/WMA and Fallon NWR area, have been shown to significantly alter amphibian diversity in other areas and have been implicated in the declines of several species of amphibians and reptiles (e.g., Bury and Whelan 1984, Rosen et al. 1995, Kupferberg 1997, and Lawler et al. 1999; as cited by Maxell and Hokit 1999). Adults bullfrogs are well known for preying on amphibians during all three life-history stages and on smaller aquatic reptiles, but larval bullfrogs also prey on eggs and larvae of native amphibians (see Maxell and Hokit for review). Furthermore, as summarized by Maxell and Hokit (1999), “eggs, larval and adult amphibians are also likely to be indirectly affected by the threat of predation due to (1) adult avoidance of oviposition sites where predators are present (e.g., Resetarits and Wilbur 1989), (2) decreased larval foraging and, therefore, growth rates as a result of staying in refuges to avoid predators (e.g., Kiesecker 1997 and Kiesecker and Blaustein 1998), and (3) decreased adult foraging and growth rates as a result of avoiding areas with bullfrogs.” Thus, bullfrogs may be a contributing factor to the marked decline in leapord frog populations in the Lahontan Valley and may be one reason why Western toads have not been recorded on the Stillwater area (E. Simandle, University of Nevada-Reno, personal communication, 1999). Bullfrogs could potentially be impacting the existing population of spade-foot toads as well.

Introduced to North America in 1890 (Chapman 1924), European starlings have had significant adverse impacts on native cavity-nesting birds throughout North America. European starlings are aggressive competitors and likely have significant impacts on the ability of native cavity-nesting birds (e.g., wood ducks, American kestrels, northern flickers) to find suitable nesting sites along the lower Carson River. Havera and Kirby (1988) noted that competition with starlings for nest sites is a continuing problem for wood ducks, citing Heusmann and Bellville 1982). In Maine, starlings were found to be the leading cause of nest abandonment in wood ducks (Allen et al. 1988). Starlings appear to have similar impacts in the Lahontan Valley (N. Saake, Nevada Div. of Wildl., personnal comm. 1995).

Although domestic cats do not appear to be a problem on the refuge at present, the potential for this could increase in the future with increased urbanization outside of the proposed refuge boundary, especially to the southwest (lower Carson River area). Domestic cats can have significant impacts on some taxa of native wildlife.

2^{ON} - Presence and Spread of Nonnative Species

The major factors that have contributed to the spread of saltcedar within the proposed boundaries of Stillwater NWR include large seed source, suitable water conditions in previously unoccupied habitant, and heavy to severe cattle grazing. The saltcedar population on Stillwater NWR/WMA, Fallon NWR, and the surrounding area is high. Each saltcedar plant can produce thousands of seeds. Saltcedar requires surface soil moisture for a long enough period to germinate and extend its tap root to a more reliable water supply. The highly dynamic nature of Stillwater’s wetlands provides ideal conditions for saltcedar germination. (Appendix J)

Cheatgrass and halogeton along roadsides are common on Stillwater NWR/WMA and Fallon NWR, and thus roads pose a way for cheatgrass to continue to expand in distribution on the area (Charlet et al. 1998).

Introduction and continued grazing by cattle is one of the most pervasive influences on riparian, meadow, and shoreline habitats. Possibly one of the most severe impacts of cattle grazing is the influence that it has on the influx and spread of other nonnative species, such as saltcedar and cheatgrass. Native plant communities impacted by diminished water availability and excessive cattle grazing likely have been key contributors to the spread of saltcedar in the Stillwater area.

Management Implications.

Two major, yet basic management implications pertaining to the above discuss is the control of saltcedar spread and the control of cattle grazing. A saltcedar control plan was recently completed for Stillwater NWR (Appendix J). As yet, controls over cattle grazing is limited, but this is being addressed in the CCP process.

Extension of the approved boundary of Stillwater NWR to include the lower Carson River would provide opportunities to restore the riparian corridor, through restoration on Federal lands (to the extent that lands are acquired from willing sellers) and cooperative efforts with private landowners and other agencies.

Based on the purposes of the refuge and other legal mandates, no attempts should be made to control mosquitos on the refuge. However, if any measures are undertaken to address mosquito concerns (e.g., mosquito abatement) the introduction of mosquito fish should be avoided, as they are nonnative to the area and can have impacts on communities of native fish and invertebrates.

No solutions have been found to effectively curtail the competition that starlings have on wood ducks (Heusmann and Bellville 1982, as cited by Havera and Kirby 1988) and other native cavity-nesting birds. Unfortunately, this can also be said for the adverse effects caused by many other nonnative wildlife species, including a host of nonnative fish that enter the refuge via drains and canals and bullfrogs.

2^{OFF} - Continued Influx of Nonnative Species

For many — possibly all — of the nonnative species impairing the approximation of natural biological diversity within the Stillwater NWR Complex, continued influx of seeds, eggs, young, and adults maintains a significant, never-ending impairment to controlling nonnatives species. All of the major nonnative species present today will remain part of the refuge's biological community.

Seeds of saltcedar, perennial pepperweed, and other nonnative species associated with marsh, shoreline, and riparian areas will continue to flow into the refuge. Some seeds, such as those of saltcedar, arrive via winds (i.e., they are airborn). Purple loosestrife has not been documented in the refuge, but occurs up-river. Thousands of acres of cheatgrass adjoin the refuge, and there are millions of acres beyond this.

European carp, mosquito fish, brown bullhead, various species of sunfish, smallmouth bass, and others enter the refuge as eggs, fry, young, and adults through the irrigation canals, drains, and river entering the Stillwater NWR. Screening efforts, in other areas, to exclude these types of fish have only had limited success. Bullfrogs can enter the refuge as larvae and as adults.

Any vacancies created by European starling control efforts would quickly be filled by a burgeoning starling population in the Lahontan Valley. Domestic cats and dogs, if found to be a problem on the refuge, could likely be successfully controlled. Because livestock are allowed on the refuge through permit only, the influx of cattle, horses, and other livestock can be tightly controlled.

Management Implications. One of the best opportunities for partnerships with surrounding landowners would be a concerted and coordinated effort to reduce the distribution and spread of saltcedar and to control perennial pepperweed and purple loosestrife before they gain a foothold in Lahontan Valley. Such efforts could potentially reduce the volume of seeds entering the refuge, thus facilitating on-refuge control efforts.

Screening and other techniques to prevent, or at least minimize, nonnative fish from entering the refuge should be explored. However, this is expensive and labor intensive.

3. Contaminants

3^E - Effects on Stillwater NWR's Natural Biological Diversity

Stillwater NWR is impacted by several environmental stressors. The combined effects of these stressors has contributed to the degradation of the system as a whole. Due to the similarity of the end results of many of these stressors and the length of time that the impacts have persisted, it is difficult to ascertain the relative contribution of each stressor to effects to habitat quality or fish and wildlife populations on the refuge. A variety of environmental contaminants have been identified in water, sediment, and biological samples from Stillwater NWR. Metals and other trace elements appear to represent the greatest threat to fish, wildlife, and habitat quality on Stillwater NWR.

A reconnaissance investigation of wetlands in and near Stillwater NWR was initiated in 1986 to determine if agricultural drainage had caused, or had the potential to cause adverse effects to human health, fish and wildlife, or affect the suitability of water for beneficial uses (Hoffman et al. 1990). Concentrations of some potentially-toxic elements (e.g., arsenic, boron, dissolved solids, sodium, and un-ionized ammonia) were found to be in excess of Federal and State criteria for the protection of aquatic life and propagation of wildlife. Sediment from some affected wetlands contained elevated levels of arsenic, lithium, mercury, molybdenum, and zinc. Additionally, concentrations of arsenic, boron, copper, mercury, selenium, and zinc in biological tissues collected from some affected wetlands exceeded levels associated with adverse biological effects in other studies. This study concluded that arsenic, boron, mercury, and selenium were of primary concern to human health and fish and wildlife in and near Stillwater NWR. Subsequent investigations have generally supported the findings of the reconnaissance investigation (Lico 1992; Hallock and Hallock 1993, Tuttle et al. 1996; Lico and Pennington 1997). Although concentrations of potentially-toxic elements have been found to be in excess of Federal and State criteria, documentation of detrimental impacts to wildlife are few.

The potential for impacts of agricultural chemicals to fish, wildlife, and habitat quality on Stillwater appears to be low. Although a variety of pesticides have been identified in drain water entering the refuge, detected concentrations were generally below levels of concern (Lico and Pennington, 1997). However, it should be noted that the sporadic use of pesticides, combined with the limited sampling and short life of many pesticides in the environment make identification of problems difficult. Therefore, agricultural chemicals can not be eliminated as a concern on Stillwater NWR.

3^ON - Unnaturally-high Concentrations of Contaminants in Wetland Waters and Soils

Contaminants are a recognized problem at Stillwater NWR, and the source of the contamination can be divided into two major groupings: (1) naturally occurring elements that have become concentrated due to human activities, and (2) contaminants that have been introduced through human activities. Of major concern in the first group are aluminum, arsenic, boron, copper, selenium, and zinc. Of major concern in the second group is mercury. For the purposes of this report, unnaturally-high concentrations of salts and alkalinity in wetland inflow are not considered contaminants. Rather, inflow that has significantly higher salinity and alkalinity than natural inflows is simply viewed as hindering or preventing the Service from providing fresh-water wetland habitat, thus hindering the approximation of the natural biological diversity associated with this habitat.

Several studies have documented concentrations of several elements in excess of Federal and State criteria. These are summarized in the preceeding section. Mercury concentrations in sediment, vegetation, vertebrates, and invertebrates have been found to be above acceptable thresholds in several wetland units within the Stillwater NWR Complex, including the Carson River.

Management Implications:

Concerns with contaminants in the first group would be reduced to the extent that contaminant concentrations in wetland inflows (3^{OFF}) were reduced. Lower water-borne concentrations would reduce deposition in wetland soils, food chain incorporation, and ultimately fish and wildlife exposure. Additionally, most elements in this group are water-soluble. Therefore, flushing would promote the gradual reduction of concentrations in wetland soils, at least in higher gradient wetlands (3^{ON}) Water management on the refuge, specifically, regular flushing of wetlands, would alleviate concerns to a lesser degree.

Unnaturally high concentrations of mercury in wetland soils is a chronic problem on the refuge that cannot be easily remedied. Mercury has a high affinity for wetland soils. Therefore, water management practices, such a flushing, will not be effective in reducing existing contamination. Conversely, mercury is mobilized from river banks and flood plains during upstream flood events. Therefore, using flood water to flush wetlands could, during exceptionally large upriver floods, increase the rate of transport of mercury to the refuge thereby exacerbating existing contamination. The natural hydrologic pattern of Stillwater Marsh may also increase the potential for adverse effects. Research has found that alternating cycles of desiccation and reflooding of wetland soils may promote conversion of mercury to chemical forms that are more biologically available and more toxic. Efforts to identify remedial and/or management options to reduce the threat of mercury to fish, wildlife, and their habitat are underway. The first goal of this research is to reduce continued mercury transport to refuge (3^{OFF}). Other options to reduce mercury exposure will also be evaluated.

<u>3^{OFF} - Inflow of Unnaturally-high Concentrations of Contaminants</u>

In most years prior to the water-rights acquisition program, the only water reaching the wetlands was agricultural drainwater. This resulted in much higher concentrations of dissolved solids than had occurred under natural conditions (e.g., an estimated 1,700 mg/l versus less than 300 mg/l) and elevated concentrations of toxic elements entering the wetlands. Several studies have shown that elevated TDS concentrations of wetland inflows have a corresponding increase in potentially-toxic elements. The ongoing water-rights acquisition program will contribute substantially to addressing this problem. It is estimated that, at the completion of the acquisition program, the average TDS concentration of wetland inflow will decline to an estimated 300-400 mg/l. One factor not readily apparent in these numbers is that, at any given TDS concentration today, the concentration of some potentially-toxic elements is higher than they would have been under natural conditions. This is due to elevated amounts of these elements entering waterways from agricultural, municipal, industrial, and other land-use practices.

Mercury initially was introduced to refuge wetlands during the late 1800s and early 1900s during the Comstock gold-mining era, prior to full development of the Newlands Irrigation Project. Significant deposits of mercury remain throughout the Carson River system below Carson City. Each major flood results in resuspended mercury, an unknown portion of which passes through Lahontan Reservoir to the Carson Division of the Newlands Project and eventually to refuge wetlands.

Management Implications:

Continuation and completion of the Lahontan Valley wetlands water-rights acquisition program will likely have the most marked positive impact to the wetlands with respect to contaminant problems. Curtailment of the acquisition program would have serious consequences to resolving contaminant issues on the refuge. All other potential solutions would require coordination or action by other agencies, businesses, and the general public, as they would necessarily be conducted outside of the refuge.

The acquisition program does not address the problem of high concentrations of mercury entering refuge wetlands during major flood events on the Carson River. Potential solutions are being explored to reduce this continued threat to wetland ecosystems. Options, all of which would require action of or coordination with other agencies or other entities, include a change in the management of controlled releases from Lahontan Reservoir dam during floods or removal of mercury from Carson River water during flood events.

4. Altered On-refuge Abundance Due to Off-refuge Land-use Practices

4^{E} - Effects on Stillwater NWR's Natural Biological Diversity

The previous factors addressed the effects of on-refuge habitat conditions on native plants and animals using the refuge, and the ultimate causes of degraded habitat conditions. This factor addresses off-refuge conditions that affect the overall abundance of native plant and animal species that would have used the refuge area under natural conditions. Altered populations of native plant and animal species affect the biological diversity of Stillwater NWR directly because the richness of species (identity and number of species) and abundances of these species are the major components of biological diversity (Noss and Cooperrider 1994, DeLong 1996).

4^{ON} - Altered Populations on Stillwater NWR

The diversity of birds on Stillwater NWR is affected by land-use practices throughout the Western Hemisphere. Many species of birds that use Stillwater NWR only spend part of their time on the refuge. Therefore, although habitat quality on Stillwater NWR plays a large role in determining the level of use by any given species, the overall population size of the species in the Pacific Flyway also is a dominant factor affecting abundance on the refuge. For instance, if a particular species or given population of a species is low, its abundance on Stillwater NWR will correspondingly be low, regardless of habitat quality on the refuge.

Other land-use practices have benefitted certain species using Stillwater NWR, such as white-faced ibis and possibly common ravens. Ethnographies of local Indians and other historical accounts suggest that bighorn sheep and pronghorn occasionally visited the area encompassed within the proposed refuge boundary. Since Euro-American settlement of the Lahontan Valley, use of the area by these species has stopped.

4^{OFF} - Off-refuge Land-use Practices

Some species of migratory birds have been adversely impacted by reduced habitat quality and availability in North America. Other species have been adversely impacted by declining habitat availability and continued use of pesticides in Central and South America.

Surrounding land-use practices (flood irrigation) appear to have increased the white-faced ibis population (Fowler 1992), but this assumes that adequate nesting habitat remains available on Carson Lake and Stillwater NWR. Fowler (1992). Thus, it is possible that use of the refuge complex by white-faced ibis is higher now than it was prior to agriculture in the Lahontan Valley.

Although additional investigation is needed, it is hypothesized that the common raven population in the Lahontan Valley is higher now than it was prior to the mid 1800s likely due to increased availability of food during critical seasons as a consequence of land fills, ranching, dairy farms, and other agricultural practices (carcasses); and an extensive road and highway system (road kills). Based on results of the North American Breeding Bird Survey (Sauer et al. 1999), the raven population throughout the Great Basin increased significantly between 1966 and 1998 (P=0.08). No direct comparisons can be made between existing population of ravens inhabiting the Lahontan Valley and the population level that existed prior to the mid 1800s, but a wealth of information on raven ecology and comparisons of existing and natural ecological conditions could be used to further examine this issue. Based on the results of three other studies (Boarman 1993, as cited by Boarman and Berry 1995) reported that elevated raven populations in the southwest are a result of human subsidies (e.g., solid waste landfills, agricultural products, powerlines).

Management Implications:

A major management implication under this factor is that managers and the public must recognize that the abundance of native species on the refuge at any given time is in part influenced by the overall population level of the species or population that uses the refuge. Another management implication is that special measures may have to be taken outside the scope of restoring natural habitat conditions to benefit certain native species whose populations are critically low as compared to natural conditions. This could possibly include the control of certain other native species that are demonstrated to have significantly higher populations than naturally occurred and that could be having undue impact on them.

5. Altered Disturbance and Mortality/Production

This section involves two main issues: effects of human disturbance, and the effects of changed predator populations and the potential effects on prey populations.

5[E] - Effects on Natural Biological Diversity

Public use on Stillwater NWR/WMA and Fallon NWR has influenced wildlife and their habitat in two primary ways: (1) by contributing to an increase in much needed water for the refuge's wetlands, and (2) affecting the behavior, activity patterns, distribution, habitat use, and related parameters. Increasing the amount of water flowing into the wetlands will contribute to resolving the problems identified in Factor 1, which addresses the most critical issue facing Stillwater NWR (water). If it were not for the support of people using the refuge for hunting, birdwatching, and other activities, it is quite likely that drainwater would continue to be the sole source of water in most years (thus contributing to resolving problems identified in Factor 3). The factor discussed in this section (Factor 5) addresses the second way that public use influences wildlife and habitat on Stillwater NWR/WMA and Fallon NWR. Human activity on Stillwater NWR can influences the Service's ability to achieve refuge purposes. A review of the scientific literature revealed that the effects of human activity include minor disruptions in wildlife behavior, changes in distribution and habitat use, reduced abundance, impaired productivity, altered nutritional status, premature departures from areas during migration, and increased mortality (DeLong 2002a). An analysis of 30 years of waterfowl surveys conducted on Stillwater NWR and other Lahontan Valley wetlands indicates that waterfowl hunting and associated activities has had an effect on waterfowl distribution and habitat use on Stillwater NWR (Bundy 2002).

The effects of human activity in wildlife habitat can be divided into six categories, as defined by Purdy et al. (1987) in their paper on human disturbance to wildlife on national wildlife refuges: (1) direct mortality: immediate, on-site death of an animal; (2) indirect mortality: eventual, premature death of an animal caused by an event or agent that predisposed the animal to death; (3) lowered productivity: reduced fecundity rate, nesting success, or reduced survival rate of young before dispersal from nest or birth site; (4) reduced use of a refuge: wildlife not using the refuge as frequently or in the manner they normally would in the absence of visitor activity; (5) reduced use of preferred habitat on refuge: wildlife use is relegated to less suitable habitat due to visitor activity; (6) aberrant behavior/stress: wildlife demonstrating unusual behavior or signs of stress that are likely to result in reduced reproductive or survival rates.

These factors, some of which were listed in Table 1, can alter biological diversity on the Stillwater NWR Complex. Applicable components of biological diversity including species richness (identity and number of species); abundance and distribution of wildlife (including habitat-use and use-days on the refuge); and biotic processes, such as migration and movement patterns (e.g., arrival and departure dates), feeding patterns and nutritional status, and production and survival rates. Related effects include the extent to which hunted species can find secure areas in high quality habitat for feeding, resting, and thermal regulation. DeLong (2002a; Appendix L) describe these potential effects in detail. The potential effects of the proposed public use program on the various components of natural biological diversity and other aspects of refuge purposes are detailed in Appendix O. The scientific information presented in the "Anticipated Impacts of the Use" column (the information of which was derived primarily from DeLong 2002) of the worksheet at the end of Appendix O (pages 81-92) summarizes the information on the potential impacts of hunting and supportive activities (e.g., boating) on the various components of natural biological diversity and other Stillwater NWR purposes.

Another potential factor is altered depredation rates of waterbird nests due an elevated common raven population (see Factor 4, above). Although no direct information is available to demonstrate that depredation of waterbird nests is unnaturally high, but an initial examination of available information (see Factor 4) suggests that the raven population is higher than it was under natural conditions, and, given the great efficiency at which ravens can locate nests, it is hypothesized that depredation rates of waterbird nests is higher than occurred naturally. Boarman and Berry (1995) cited several studies in which common ravens, a native species in all of the cited study areas, was having serious impacts on other native wildlife species, due to the significant increase in raven populations which in turn has been the result of human alteration of the local ecosystems. At this time, site-specific information does not exist to indicate whether nest depredation or mortality rates are any different on Stillwater NWR than they would be under natural conditions. Additional investigation is needed.

5^{ON} - Human Disturbance Rates on the Refuge

Past and ongoing human activities that result in wildlife mortality or disturbance to wildlife (e.g., driving, boating, hunting, fishing, muskrat trapping, wildlife viewing, camping, activities of refuge personnel) can affect biological diversity on the Stillwater NWR Complex as briefly noted above. The extent of effects are dependent on how the public use program is designed and individual public uses are managed.

Existing Public Use Program: Outside of national laws, State and Federal hunting regulations, and a sanctuary, there are few restrictions on wildlife-dependent recreational uses and other uses on Stillwater NWR and Stillwater WMA. The open area (non-sanctuary) is open to public use 24 hours per day, 7 days per week; there are no restrictions on the number of people using the marsh or other habitats; and, although vehicles are restricted to open roads, the road network is extensive and people are permitted to walk and boat throughout the entire open portion of the marsh year-round. The entire area is closed to off-road vehicle use, but, despite this restriction, off-road vehicle use continues in some areas, especially in the sand dunes. Camping is permitted throughout the area, although little camping occurs outside of the Indian Lakes area during the summer and in the area of Stillwater Marsh during the waterfowl hunting season. The sanctuary, which is closed to all public access, has remained in the same place since 1949. Nearly half of the sanctuary consists of the refuge's regulating reservoir. The sanctuary traditionally has encompassed 30-60 percent of the available wetland-habitat in Stillwater Marsh (although no minimum has been established).

Hunting is permitted throughout the open area (i.e., up to 72 percent of Stillwater Marsh), all day, seven days per week, and boats, including airboats, are allowed on all wetland units with few restrictions. Although hunting pressure has been light to moderate during the past few years, due to reduced interest after an eight-year drought and extensive acreage after five spill years, hunting density and pressure is anticipated to increase as wetland-habitat becomes more reliable. An estimated 20 percent of hunters used boats in the 1999-2000 season (Chaney 2000). In the 1970s, when the hunt area regularly exceeded 10,000 acres of wetland-habitat, hunter densities of 1 hunter per 30 acres was not uncommon. Hunter numbers may not return to what they were in the 1970s, but hunter densities can. There is no minimum amount of sanctuary that must be provided during the hunting season under the existing program and during the past 10 years, the amount of the amount of sanctuary provided has varied considerably. Generally, when less than 3,000 acres of wetland habitat exists during the hunting season, roughly 50-65 percent of the habitat was provided in sanctuary. When total wetland-habitat acreage is between 4,000 and about 10,000 acres, about 35-40 percent of the habitat was in sanctuary. Above 11,000 acres of wetland-habitat, less than 30 percent was in sanctuary.

Development of a Problem Statement:

Enactment of Public Law 101-618 in 1990 and the National Wildlife Refuge System Improvement Act in 1997, and the new requirements they contain for Stillwater NWR resulted in a shift in the management authorities governing the management of the Stillwater NWR. Until the comprehensive conservation plan is approved and implementation begins, Stillwater NWR will continue to be managed under most provisions of the 1948 Tripartite Agreement. Under this agreement, hunting has been the priority public use and it has had coequal status with wildlife conservation. Many other recreational activities have been allowed on Stillwater NWR, Stillwater WMA, and Fallon NWR, including fishing, wildlife observation and photography, camping, boating, and horseback riding.

The direction provided in Public Law 101-618 and the Refuge System Improvement Act is clear: the conservation of native fish, wildlife, plants, and their habitat is the fundamental mission of Stillwater NWR. As articulated in the Service's *Fulfilling the Promise* document (USFWS 1999), "...the law of the land now clearly states that their needs [fish, wildlife, and plants] must come first..." It is also clear that another very important goal of Stillwater NWR is to provide opportunities for compatible wildlife-dependent recreation. Just as the Refuge System Administration Act calls for refuge managers to facilitate opportunities for wildlife-dependent recreation, it requires managers to make sure that these and other such uses are compatible with refuge purposes before they are permitted. The Act notes that hunting, fishing, wildlife observation and photography, and environmental education and interpretation have generally been found to be compatible uses of the Refuge System. The Act recognizes, however, that not all of these uses will be found compatible on all refuges. This is illustrated by an example provided of Blackwater NWR, Maryland, in which hunting is not permitted (House Report 105-106). Some refuges do not provide any public access.

The Act also recognizes that, although a use may be identified as generally compatible on a given refuge, whether it is actually compatible depends on how the program for the use is designed and operated. The design of the existing public use program reflects the philosophy of the 1948 Tripartite Agreement. The current planning process has entailed evaluating and designing a public use program according to the standards set by Public Law 101-618 and the Refuge System Improvement Act.

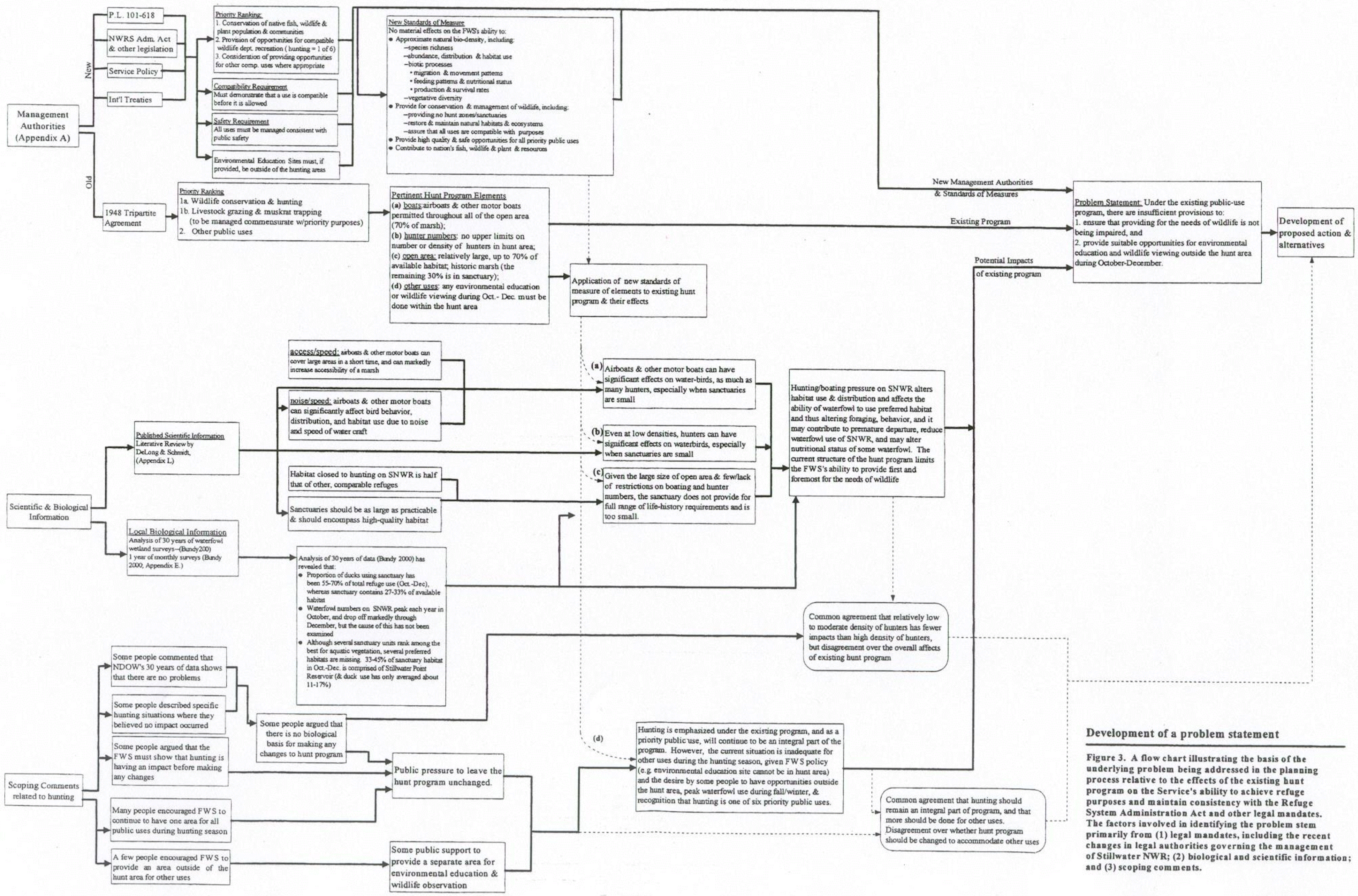
The disagreements that the shift in management authorities has stirred, especially with respect to hunting on Stillwater NWR, warranted a closer examination. Given the many factors involved, a flow chart was developed to assist in explaining the basis of the underlying problem that the Service must address in the planning process with respect to the public use program and its compatibility during the hunting season (Figure 3). This chart addresses factors beyond the scope of natural biodiversity; the other purposes of Stillwater NWR were also addressed. This underlying problem is summarized as follows:

> Under the existing public-use program, there are insufficient provisions to (1) ensure that providing for the needs of wildlife is not being impaired, and (2) provide suitable opportunities for environmental education and wildlife viewing outside the hunt area during October-December.

Many factors are involved, including the change in management authorities governing the management of the area, biological and scientific information, professional judgement, and other input received during the scoping process. The first item in the problem statement involves three main interrelated factors: (1) boating and road access, (2) hunter density and distribution, and (3) amount and quality of sanctuary. During the past several years, hunter densities on Stillwater NWR have been relatively low, and it is generally recognized that a low density of hunters affects waterfowl and other wildlife less than a high density of hunters (DeLong 2002a, for review).

Sanctuary is not as high of a concern if hunter density is low enough to allow waterfowl to find high-quality habitat in relatively undisturbed areas outside the sanctuary. However, even a few airboats and other motorized boats can counteract low hunter density, meaning that more sanctuary would be needed to ensure that birds can readily access high-quality habitat in a relatively undisturbed area. Extensive published scientific information summarized by DeLong (2002a; Appendix L) suggests that the effects of liberal boating in Stillwater Marsh during the hunting season may have as much or more to do with altered waterfowl distribution and habitat use during the hunting season (Bundy 2002) than the effects of hunting by itself. Boating effects wildlife in three main ways: speed, noise, and increased access into all habitats open to boating. With few boating regulations, the demonstrated effects that even small numbers of boaters can have on wildlife, and the vast majority of wetland-habitat open to boating on Stillwater NWR, there are few assurances that waterfowl and other wildlife will not be unduly impacted. Road access is another factor influencing hunter distribution and density. There are several concerns related specifically to the adequacy of the existing sanctuary, and these are discussed further in Appendix O. The effects of boating, hunting, wildlife observation, and other activities are addressed in Appendix L and compatibility determinations (Appendix O), and therefore are not discussed in detail here.

The second part of the underlying problem addresses environmental education and wildlife observation. Service policy requires that environmental education sites be provided outside the hunt areas, which is highly pertinent to Stillwater NWR as environmental education is the only priority public use specifically identified in refuge purposes. At present, there are no places outside the hunt area for people to view birds or for the Service to take school groups and other groups during the hunting season, except one small parking area next to the maintenance shop. Although several individuals and groups have commented that this is not a problem because combined use of the same area tends to maintain unity and cohesion among the different user groups, other people have expressed that they would like opportunities to be provided outside the hunt area during the hunting season.



Development of a problem statement

Figure 3. A flow chart illustrating the basis of the underlying problem being addressed in the planning process relative to the effects of the existing hunt program on the Service's ability to achieve refuge purposes and maintain consistency with the Refuge System Administration Act and other legal mandates. The factors involved in identifying the problem stem primarily from (1) legal mandates, including the recent changes in legal authorities governing the management of Stillwater NWR; (2) biological and scientific information; and (3) scoping comments.

Management Implications:

Effects of human activity on Stillwater NWR are directly influenced by the way in which public uses are managed on the refuge, including adjustments that can be made to account for increased or decreased numbers of visitors. Because information on site-specific impacts of human disturbance is limited, the biological program must be reassessed to better account for this issue. Furthermore, adaptive management, combined with explicitly stated success-criteria and thresholds, must be a key part of the comprehensive conservation plan.

Figure 4 graphically illustrates the relationship among the effects of boating (and other modes of accessing the marsh), hunter density, and the amount of sanctuary needed (the figure represents a conceptual synthesis of pertinent information contained in DeLong 2002a). These factors must be weighed in developing a hunt program that is compatible with Stillwater NWR purposes. Generally illustrated is that the need for sanctuary is somewhat lower for an area comprised of large wetland units with relatively low hunter density as compared to an area comprised of many small wetland units and many hunters, although the allowance of airboats and other motorboats would tend to equalize the effects. Even though hunter density is low to moderate on Stillwater NWR, relatively unrestricted boat access has the potential to offset this factor.

Therefore, under anticipated average water conditions (or better) and assuming relatively low hunter densities, the issue in many ways boils down to a relationship between the level of boating restrictions and amount of sanctuary (Figure 4). The more liberal the boating regulations are, the more sanctuary is needed. Conversely, the more that boating access, speed, and noise are minimized, the lower the needs are for sanctuary. In wetland areas allowing boating access, the most effective way to mitigate for the adverse impacts of boating is to provide areas of high-quality habitat that are inviolate to boating (Havera et al. 1992). Other ways to reduce the adverse effects of boating include overwater speed limits and no wake restrictions (to minimize speed) and limits on decibels of noise produced by motorboats and limits on the horsepower of motorboats, also to reduce noise output. Limitations on horsepower may or may not reduce noise produced by motorboats because some motors do not have mufflers.

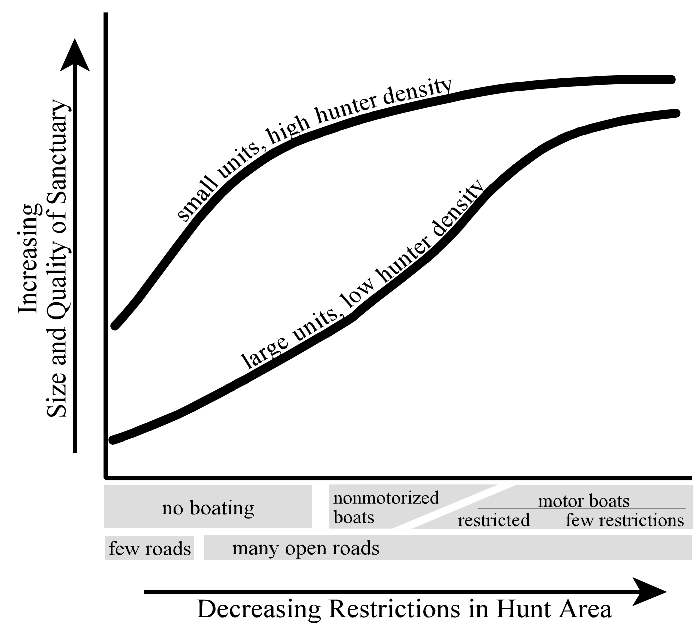


Figure 4. Graphic illustration showing the general relationship between the level of restrictions in a hunt area and the amount of sanctuary needed to counterbalance the effects of disturbance, assuming wildlife welfare is the highest priority, under two different scenarios.

Altered Production/Mortality Rates:

A related issue, not addressed in Appendix L (DeLong 2002a), is the extent to which populations of predatory species have changed and how altered populations of these species have affected the productivity or survival of their prey species on the refuge. Again, very limited site-specific information exists for the refuge and additional information is needed (however, see previous discussions of ravens). To the extent that raven populations are higher, depredation of waterbird nests may be higher than it would be under natural conditions, regardless of nesting-habitat quality. This was not identified as a core problem because alterations to wildlife habitat likely are more important factors influencing waterbird production. Furthermore, off-refuge land-use practices and activities (land-fills, agriculture, livestock production [livestock carcasses], roads and highways [roadkills]) likely are the underlying causes for any population changes. Furthermore, on-refuge activities may contribute to elevated depredation rates by common ravens. Although ravens are highly effective at locating nests from the air (personal observ.), elevated perches near waterbird nesting areas increases their efficiency at finding nests. Therefore, directional signs along roads, spoil piles along canals, possibly satlcedar, and other things providing elevated perches would appear to contribute to any elevations in nest depredation. Human activity (e.g., recreators and refuge staff) in areas of waterbird nesting can also assist ravens in locating nests due to incubating birds being flushed from nests (see DeLong 2002a for review).

5^{OFF} - Public Interest in Using Refuge (local-global) and Altered Populations of Predators

Populations of Fallon, Fernley, Reno, and Carson City are growing and visitation by other nearby population centers (e.g., California's Central Valley and San Francisco Bay) appears to be increasing. It is anticipated that the number of people using the Stillwater NWR Complex for hunting, wildlife observation, and environmental education will continue to increase as nearby cities grow and wetland-habitat acreage becomes more reliable from year to year.

Management Implications:

Managers must recognize increasing populations and subsequent rises in demands for wildlife-dependent recreational opportunities, which could result in the establishment of wildlife-viewing trails, blinds for wildlife photography and wildlife viewing, and wildlife observation towers, all geared toward enhancing opportunities for the general public. Design and placement of these facilities should be done in a way that minimizes the adverse impacts that can result from an unstructured approach to providing such opportunities.

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